

DOCUMENT RESUME

ED 342 365

IR 015 396

AUTHOR ChanLin, Lih-Juan; Okey, James R.
TITLE Formative Evaluation of Outcomes, Products, and Processes During Instructional Development.
PUB DATE Nov 91
NOTE 15p.; Paper presented at the Annual International Conference of the Association for the Development of Computer-Based Instructional Systems (33rd, St. Louis, MO, November 11-14, 1991).
PUB TYPE Speeches/Conference Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Courseware; *Formative Evaluation; *Instructional Development; Instructional Effectiveness; Instructional Material Evaluation; Interaction; Material Development

ABSTRACT

Traditional formative evaluation of computer assisted instruction (CAI) products has focused on assessing learner achievement of objectives and the inferential use of this information to make revisions. A more comprehensive approach to formative evaluation includes traditional learner achievement assessment but adds assessments of the development process and of the product itself. Formative evaluation should begin well in advance of a trial product being ready for learner tryout. As soon as goals are set, instructional analyses carried out, or learner characteristics considered, formative evaluation of the decisions made and processes followed should be begun by a development team and continued throughout the development process. Additionally, the product should be examined to ensure that it includes characteristics and features consistent with learning theory and appropriate to the content being taught. The proposed outcome-oriented, product-oriented, and process-oriented approach to evaluation uses learners as a source of evaluation information, but relies as well on content and instructional development experts. Together, the three perspectives provide a comprehensive approach to the development of effective and efficient CAI materials. (15 references) (Author/DB)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

☐ This document has been reproduced as
received from the person or organization
originating it.

☐ Minor changes have been made to improve
reproduction quality.

• Points of view or opinions stated in this docu-
ment do not necessarily represent official
OERI position or policy.

ED342365

Formative Evaluation of Outcomes, Products, and Processes During Instructional Development

Lih-Juan ChanLin & James R. Okey
Department of Instructional Technology
University of Georgia

A paper presented at the 33rd International Conference of the
Association for the Development of Computer-Based Instructional
Systems. St. Louis, MO. November 1991

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

Lih-Juan ChanLin

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

2
BEST COPY AVAILABLE

112015396

Abstract

Traditional formative evaluation of CAI products has focused on assessing learner achievement of objectives and the inferential use of this information to make revisions. A more comprehensive approach to formative evaluation includes traditional learner achievement assessment but adds assessments of the development process and of the product itself. Formative evaluation should begin well in advance of a trial product being ready for learner tryout. As soon as goals are set, instructional analyses carried out, or learner characteristics considered, formative evaluation of the decisions made and processes followed should be done by a development team throughout the development process. Additionally, the product should be examined to assure that it includes the characteristics and features consistent with learning theory and appropriate to the content being taught.

The three pronged approach to evaluation proposed here uses learners as a source of evaluation information but relies as well on content and instructional development experts. Together, the three perspectives provide a comprehensive approach to the development of effective and efficient CAI materials.

Formative Evaluation of Outcomes, Products, and Processes During Instructional Development

Lih-Juan ChanLin & James R. Okey
Department of Instructional Technology
University of Georgia

Formative evaluation is a critical process in the development of computer-assisted instruction (CAI). Conducting evaluation during program development gives the decision makers and development staff a chance to examine the effectiveness of a program. It also provides an opportunity to scrutinize the assumptions and activities that underlie a program (Fitz-Gibbon & Morris, 1987). Formative evaluation during instructional development has typically focused on tryouts of instructional products to determine if students learn. Beyond that goal of assessing learner effectiveness is the need to evaluate the instructional product itself and the process used to produce it. The purpose of this paper is to describe how each of these three aspects of formative evaluation can work together to aid in the development of effective and efficient instructional materials.

Outcome, Product, and Process Evaluation

During the development stage, evaluation can be employed for formative purposes from three different approaches: outcome-oriented, product-oriented, and process-oriented. From the outcome orientation, formative evaluation can be defined as the process of determining the acquisition of the learning outcomes the instruction is intended to impart. The focus of this orientation is to gather information about how well students learn from the instructional content provided.

From the product orientation, the instruction needs to achieve an overall design standard. Formative evaluation can be used to assess the quality of the product, in reference to the content and the way instruction should be organized and presented. The focus of this orientation is to gather information about how well the program provides intended information and interactions.

From the process orientation, the overall development process needs to achieve effectiveness in reference to the effort and time expended. Formative evaluation can be used to systematically review the process of development in order to gather information about the effectiveness of the development procedures followed. The focus of this orientation is to gather information about how

well the development processes are conducted to make effective use of time and resources.

An evaluation plan should plan for different assessments and use the information gained to review and revise the product and processes to achieve the purposes of helping learners learn and making the processes effective. Based on these three different orientations, formative evaluation is discussed from the three perspectives.

Planning for Assessing Learning Outcomes

Outcome-oriented assessment was first proposed by Tyler (1942). His approach to educational evaluation involved setting educational goals according to an analysis of students, society, and the subject area. At the end of an instructional program, student achievement is measured in order to see whether established goals are achieved. From a outcomes-oriented approach, instruction is designed to move students from their original states to desired levels. Learning is evidenced by improved performance on the part of the students. In order to enable instruction to achieve outcomes as intended, an evaluation plan needs to identify ways to determine the effectiveness of the instruction in reference to student performance.

Formative assessment can provide information about whether students have achieved the set of capabilities defined by the instructional objectives, and whether or not the lesson needs to be embellished or revised in order to make the information more accessible to learners. Testing as a formative purpose is the most frequently used way to assess student learning outcomes. The design of test items should reflect the intended instructional objectives prescribed earlier. With the purpose of identifying what learners know about the subject, prerequisite skills need to be assessed by providing pretest items at the beginning of a lesson. At the end of the section instruction, the learning capabilities then should be assessed by post-test items. Pretest and post-test results can be a valuable indication to identify possible problems within the instruction during the try-out stage. If learners don't pass the post-test, remedial materials should be provided within the instruction. If most learners can answer the post-test items, does that necessarily mean that the instructional materials are effective? Could it be because the lessons are teaching what they already know? Or, could it be that test items are too easy? To be an accurate indicator, test items need to be evaluated based on the criteria of validity and reliability.

The objective-referenced orientation to assessment overtly emphasizes the concept of validity in performance measurement. One important issue in test validity (Gagné, Briggs and Wager, 1988) is to keep the capabilities verbs and the actions to demonstrate the learning capabilities are congruent

with objective and test conditions. Validity is assured when the assessment procedure results in measurement of the performance described in the objectives.

Reliability refers to the consistency of measurement. To reflect the reliability of the test, a single item is usually not sufficient to make a confident conclusion that a student has mastered a performance. It is necessary to consider how many items correct indicate dependable mastery.

It should also be true that the test used to determine program effectiveness should be made neither easier nor more difficult than the objectives. In the formative orientation, testing is a tool rather than an aim. The purpose of formative evaluation is not to rate students based on their scores. Instead, it is to discover which objectives are achieved and which are not. From another point, it also helps to diagnose learning problems, such as the time needed for student to learn the knowledge, or to determine if there is any missing prerequisite knowledge or skills to include in order to achieve the objectives.

With reference to different kinds of learning capabilities, Gagné, Briggs, and Wager (1988) observe that different procedures are required in criterion-referenced testing to determine mastery of different learning capabilities. For example, to determine the assessment of verbal information, the indicators of mastery are often direct and overt. In contrast, the indicators of cognitive strategies or attitudes are somewhat indirect and often require a sequence of inferences. In cognitive strategies, simply providing a right answer is not sufficient to serve as an indicator of mastering the skills in assessment. Instead, how well do students employ the taught strategies usually requires deeper observations or questioning in order to gather more accurate data. Consequently, testing higher level outcomes in CAI lessons is sometimes complex and requires multiple criteria to determine the mastery level.

Assessing Product Effectiveness

Product effectiveness of CAI materials relies on the processes employed in producing instruction. The information provided from the processes of front end analysis, needs assessment, learner analysis, instructional analysis, objective setting, and instructional strategy selection all apply to the production of appropriate materials for target learners' needs.

Successful instruction should include the characteristics of presenting information that can motivate students to learn, guiding student through the interactive nature of the instructional materials, practicing the skills to help student become fluent with them, and assessing student

performance through the use of a test (Hannafin & Peck, 1988). However, the assessment processes employed are varied among tutorials, drills, simulations, and exploratory environments. Tutorial lessons should be judged based on how well the lessons are arranged and organized and whether the directions are well presented to guide students to learn. Drills should be judged based on how well the program generates practice questions, and whether the practice reflects the intended learning outcomes. Simulations should be judged based on how well the programs simulate real learning situations and provide precise communication, and whether or not they encourage real learning experiences. Exploratory computer environments are assessed on the degree to which they provide an interesting and challenging format in which desired paths and goals are available and possible to negotiate.

Issue of control

"A good interactive program is easy to get into, easy to get around in, and easy to get out of" (Flagg, 1990). An ideal CAI program should provide users with information about how to navigate through the system. It should also furnish users with the opportunity to play an active role in accessing information and making decision about their own learning. System control provides users with guided instruction through the process of learning. Learner control provides users with a sense of self-control and self-regulation. Although these two designs approach learning differently, they both provide valuable aspects in achieving effective learning. However, caution is needed about when and where to provide users with these control options and whether they are appropriate to the target learners. Several questions can be addressed in a formative approach of assessment:

- Do learners know how to start the program, what to do next, and how to proceed through a decision-making process?
- Are the directions about where to go and what options are available clearly stated?
- Can learners access information they need easily?
- Does the program provide flexibility for learners to adapt their own needs?

Text Layout

In presenting information, clear and effective communication is important. The effectiveness of presentation depends not only upon the skill of writing but also the strategy of presenting the information. Within a CAI lesson, text can be considered the most common way of presenting information. Since the amount of text that one can display in one screen is much smaller than on a page, organizing text into a structured and concise layout is crucial (Hartley, 1987). The provision of concise and attractive layout not only encourages motivation to learn, but also saves time for reading and delivering information (Streit, Davis, & Lander, 1986). For formative purposes, the

following questions might serve as guidelines to improve the readability and retrievability of written text.

- Does the program use clear, familiar words to present ideas and information?
- Has the text been formatted into a structured way for easy reading?
- Are colors, labels or arrows used for highlighting important information?
- Does the program use charts and tables to support the message whenever necessary?
- Are the text layout conventions consistent and appropriate?

Graphic Representation

To provide a motivating environment, instruction should be appealing to learners (Keller, 1988). Including graphics, for example, in computer reading materials enhances learning when properly used. However, graphics might be detrimental when improperly used (Dwyer, 1970). Design of graphics should be based on what is important in the text, and avoid focusing attention on unimportant information (Hannafin & Peck, 1988). The great caution needed is to avoid misleading or confusing learners and focusing graphics on the instructional purpose. To assess graphics from a formative viewpoint, the following issues should be stressed:

- Are the graphics relevant to the content and instructional purpose?
- Do the graphics use subjects that match with learners interests?
- Do the graphics facilitate comprehension of the instructional content?
- Are the graphics presented on the same display as corresponding text information?
- Do the graphics present appropriate amounts of information for students to digest ?
- Are the graphics well produced?

Interaction

Well designed CAI programs anticipate learners wishes, responding to requests with suitable and timely action to initiate help or redirect learning efforts (Flagg, 1990). Feedback in computer assisted instruction is a key element for providing interactions and encouraging active learning. In any computer assisted instruction, few skills can be acquired satisfactorily simply through providing information about them. Most require interaction between the instruction and learners through practice and feedback. Feedback usually provides information about how successfully a skill has been acquired by learners. It can be considered a way to help determine the mastery of certain skills and concepts and to provide an indication about how performance can be improved. As suggested by Hannafin and Peck (1988), feedback needs to be frequently provided during CAI lessons. The design of feedback needs to include the considerations of use in different types of situations for achieving meaningful communication with learners: (1) "Feedback following format errors" is to prompt learners to correct wrong answers; (2) "Feedback following correct responses" is to confirm their correctness; (3) "Feedback following neutral responses "(such as

"Thank you!" or "Good!") is to provide non-judgemental responses for user interaction; and (4) "Feedback following content errors" is to help learners correct the right format but wrong content answers. The notion of considering different types of feedback is that the students need to be motivated to respond, and they need to be told not only "right" or "wrong" but also "why" an answer is right or wrong. During formative assessment, following aspects also need to be evaluated:

- Do users receive timely feedback appropriate to their needs?
- Is the feedback complete, correct, concise, and comprehensible for learners?
- Does the feedback encourage a positive attitude toward learning?
- Is the feedback appropriate to the actions that learners take?

Assessing Process Effectiveness

Process evaluation is aimed at understanding the internal dynamic of how a program is operated (Patton, 1990). Formative evaluation can be employed at any time, during any stage of the instructional development process. The tools used in formative process evaluation can be observation, questionnaires, interviews, or discussions with development team members or external experts. Process study of programs focuses on the following kinds of questions: What are the things people experience from developing the program? What are the strengths and weaknesses of the procedures being used? How is the program actually being used? These data gathered serve the function of self-monitoring within the program. As suggested, these monitoring processes should start at the early planning stage and continue throughout the life of a program (Cannings & McManus, 1987). Formatively, they provide continual feedback to design teams from different aspects so that the development processes can be conducted more effectively. Several tools can be used to meet this purpose:

Check lists: A simple checklist that keeps time line and major events might serve as a guideline to what is expected to be accomplished, and a self-administered instrument to keep track of the development progress. It also helps to identify possible problems or difficulties in later development stages.

Meetings: A lot of good ideas or recommendations might be shared through meeting and discussion. Meetings within a design team can smooth conflicts between members and serve a communication function. Thoughts from people outside the team can help identify important factors that might not be obvious to the design team.

External connections: Keeping contact with external experts or other design teams provide ways to obtain useful data from their design experience. Usually, it takes more time to learn things from experience than to learn from being told. A lot of the same mistakes can be avoided if advice is provided in advance.

Formative Assessment of CAI Development Processes

Analysis

During the analysis stage of development, formative evaluation can be employed in determining whether the tools used for identifying the instructional goal or gathering learner entry behavior can accurately reflect the real picture of the target environment. Is the information gathered from the target population for whom the instruction is designed? Does the instructional analysis identify all prerequisite skills needed for achieving learning goals? Have all external factors that might influence learning of the materials been considered? What is the feedback from sponsors? How can the ideas from the environment integrate into the development process?

Before the program is designed and produced, an intensive process of studying, defining, and reviewing is employed to assess learners' needs, marketing considerations, and the strengths and interests of the area that the software is designed for. Consulting with outside experts and conducting literature reviews in the relevant content domain can assess a multi-dimensional knowledge in the area. The process not only helps design teams to obtain a better understanding about the content area but also gather and integrate points of view from various fields including education, psychology, cognitive science, and computer science in order to initiate an effective design.

Design

Once the product point of view has been formulated and the content research is complete, a brainstorming process should be generated by the development team. This process involves identifying resources and expert consultants as well as prototyping the design ideas (Flagg, 1990). During the design stage, the formative evaluation process is employed to help determine whether the design treatment is appropriate to target learners, and whether the content outline is designed in congruence with learning goals and objectives identified from needs assessment. Often the brainstorming process may end up with several design ideas. However, those ideas need to be reviewed from a more realistic point of view, such as: Will learners want to use this activity? Will they appreciate particular features of the design? Will the design achieve expected interaction with target learners? Is this interaction feasible? What are other alternatives to specific design problems?

To assess this information, a simple mockup may be employed among target learners to try out the design prototype. With the assessed information from the mock try-out, the design team can build a precise and detailed blueprint for the program. The blueprint might cover all the computer screens needed, placement of sound effects and specification of every interaction within the program. Before production, it might be a good idea to send out the design blueprint to external experts (curriculum specialists or content experts) to have them preview the outline and provide feedback, so that revision may be made before putting effort into production. Within the team, it is also necessary to set up a time line and allocate effort that should be spent on different portions of the instruction.

Production

During the production stage, the programmer and graphic artist begin to write the code and produce the artwork for the program. The formative evaluation is employed to monitor the production process and make good use of effort spent. Although the steps followed in the production stage are carried out based on the designed blue print and the information provided in the analysis and design stage, the design team should be also open to new ideas, and revising the development plan based on their own experience. From actual production, the issues of control, text layout, graphics, and interaction should be reviewed not only based on what research recommends, but also tempered with the reactions obtained from learners. A try-out with target learners during the production stage can help identify design problems as early as possible, such as: Is the system created too complex for learners to handle? Are the images used comprehensible to learners? Are the instructions worded appropriate to learners? Is the length of the instruction appropriate to learners?

Evaluation

During evaluation, the instructional program is almost complete. The development team focuses their efforts on how the program is actually used by target learners. Different from the try-out in the design stage or production stage, the entire program is ready to test among students at this point. The last formative assessment is to obtain information for making final revisions. If various pieces of the program have been carefully tested during the design and production stages, rarely will the final try-out result bring surprises about some unforeseen difficulty with the program (Flagg, 1990). A well-planned formative evaluation should be embedded with several try-out processes in order to detect problems as early as possible.

Trying-out Instruction

Among various tools for formative assessment, learner try-outs are considered the most direct way to assess program effectiveness. When instruction is evaluated, the learner is also the center of focus within the process. The effectiveness of the instruction is reflected by measuring the behavioral change among learners. (Hannum & Briggs, 1982). If the instruction does not facilitate knowledge acquisition or attitude change, then the designed instruction should be modified (Dick, 1977; Gagné, Briggs, & Wager, 1988). Sometimes, it is hard to image that an instructional product is developed without an opportunity to access its target learners until the last stage of the development process.

Suggested by Dick & Carey (1985; 1991), there are three basic phases of formative evaluation: one-to-one evaluation, small group evaluation, and field trials. Once a program is produced, it is not necessarily ready to be used among all target learners. Since editing and revising CAI materials becomes more difficult in the later stage of product development, a preliminary draft of designed instruction can be tried out among target learners so that problems can be identified at the earliest stage (Flagg, 1990). Although, theoretically, advice from outside experts, or reviews from the literature can provide principles or recommendation from a formative basis, continuous contact with learners is the most direct indication for assessing the information. During the whole instructional development processes, the development team might overlook some important elements or constraints that occur in the real instructional setting. Through different kinds of try-outs, these problems may be avoided.

One-to-one try-out

The purpose of one-to-one try-outs is to yield information on how clear the information and instructional procedures are to the learners (Dick & Carey, 1990). Conducting effective one-to-one evaluation depends on the ability of the evaluator to establish a good relationship with learners, and then to interact effectively with them. Since the purpose of one-to-one try-outs is to find out how students interact with the instructional materials, the testing condition should be arranged in a way that is most close to the real instructional environment. Before each one-to-one try-out, the evaluator should have a strategy in mind about how the interaction will take place. During the evaluation, it is important to provide an atmosphere of acceptance and support for any negative comments so that learners feel free to express their difficulties and problems with the instruction.

Small-group try-out

The purpose of small-group trials is to gather learner performance and attitude data (Dick & Carey, 1990). Small -group try-outs are also employed to confirm the results gathered from one-to-one try-out, and at the same time help categorize different learning paths that might be observed from learners (e.g., some students subconsciously commit certain kind of errors). Based on the different learning paths identified, alternative interactions might be included in the instruction. The learners who participate in small-group evaluations should represent the target population as well as possible. Several sampling strategies can be engaged in for the purpose of selection: random sampling, stratified random sampling, or random clustered sampling. The choice of the sampling strategies depends on which one can best reflect the target population. The difference between small-group evaluation and one-to-one evaluation is that the materials used for small-group evaluation should be a revised version which includes changes made from the one-to-one evaluation. However, they are still in the formative stage of development and it is necessary to obtain feedback on how they can be improved. Attitude questionnaires can also provide learners reactions to the instruction to help determine what can be improved.

Field trial

Field trials are the final stage of formative evaluation and also the final stage of product development. The purpose of field trials is to use a learning situation that closely resembles the target environment, so that the ultimate use of the CAI materials in the intended learning situation can be studied. Once the changes have been made from one-to-one and small-group try-outs, the program is considered completed with the possible exception of some fine-tuning. Before releasing the product to the market, the material should be tested over time in the target settings. In the field trials, questionnaires and interview data are gathered from everyone involved in the implementation of the CAI product. In addition, evaluators should also employ an unobtrusive observation on the use of the program including the interaction between the teacher, students, and the programs. Although the material is designed for student use, teachers usually play an very important role in the implementation of CAI products. A field trial can help identify any assistance teachers need when the product is implemented in classrooms.

Revision of Instructional Materials

Patterson and Bloch (1987) view formative evaluation as a process involved with expert review, student try-outs, debriefing results, and revising materials. Formative evaluation in developing CAI is an on-going process to improve the developed materials in order to promote learning achievement and to improve the development processes in order to make the time and effort effectively used.

The formative information gathered from interviews, questionnaires, or pretest/post-tests in one-to-one/small-group trial/field trials should be integrated into the whole development process. The data gathered in the analysis, design, and development stages can be used for self-monitoring. The on-going formative evaluation is a self-monitoring process which allows certain degrees of communication with the environment or from outsiders, and brings those ideas into the system to improve the development process.

The data gathered in the various evaluation stages can be used as indicators for making final revision of the CAI materials. Through the actual trying-out with learners in the real environment setting, how the program is actually implemented in the real setting can be pictured. The integration of teachers, peers, and other environment factors can also provide the development team valuable information for the final tuning of their product. When the final testing is completed and the results are analyzed, it might be too late to make substantive changes in the program, because of the budget and schedule. However, if various try-outs have been included in the formative process, changes can be made in the earlier development stages. Final revision then might not require drastic changes to an entire program.

Summary

Formative evaluation is essential to efficient development processes and effectiveness of designed products. Practically, formative evaluation should be viewed as an integral part of the instructional development process, and are actually taken place whenever modifications and revisions are needed. Approaches to formative evaluation can be employed from three perspectives: an objective orientation, a product orientation, and a process orientation. Objective-oriented evaluation counts on well-designed products and systematic design processes to accurately reflect students' achievement from intended learning. Product-oriented evaluation depends upon precise assessment of instructional objectives and well-structured development processes to achieve the design criteria. Process-oriented evaluation provides means to achieve effective design of CAI products. A design team employing a multi-dimensional formative approach along these three dimensions increases their chances of producing effective instruction in an efficient manner.

Try-out processes are the most direct means of obtaining formative data. Practically, these tryouts should not be separated from the development process. Instead, they should be employed whenever is necessary to gather formative data. Following try-outs, revisions of the materials should be made as early as possible so that efficient use of time and effort can be achieved.

References

- Cannings, T. & McManus, J. (1987). Facilitating and monitoring a computer education program. In R. Bennett (Ed.), Planning and evaluating computer education programs (pp. 145-162). Columbus, OH: Merrill Publishing Company.
- Fitz-Gibbon, C. & Morris, L. (1987). How to design a program evaluation. Newbury Park, CA: Sage Publications, Inc.
- Dick, W. & Carey, W. (1985). The systematic design of instruction (2nd ed.). Glenview, IL: Scott, Foresman and Company.
- Dick, W. & Carey, W. (1991). Formative evaluation. In L. J. Briggs, K. L. Gustafson & M. H. Tillman (Ed.), Instructional design: Principles and applications (2nd ed), pp. 227-267. Englewood Cliffs, NJ: Educational Technology Publications.
- Dwyer, F. (1970). Exploratory studies in the effectiveness of visual illustrations. Audio Visual Communication Review, 18, 109-122.
- Flagg, B. N. (1990). Formative evaluation for educational technologies. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Gagné, R., Briggs, L. & Wager, W. (1988). Principles of instructional design (3rd ed.). Orlando, FL: Holt, Rinehart, and Winston.
- Hannafin, M. & Peck, K. (1988). The design, development, and evaluation of instructional software. New York: Macmillan Publishing Co.
- Hannum, W. & Briggs, L. (1982). How does instructional systems design differ from traditional instruction? Educational Technology, January, 9-14.
- Hartley, J. (1987). Designing electronic text: The role of print-based research. Educational Communications and Technology Journal, 35(1), 3-17.
- Keller, J. (1988). Motivational design. In D. Unwin & R. McAleese (Ed.), The encyclopedia of educational media communications and technology. (2nd ed.). (pp. 406-409)
- Patterson, A. & Bloch, B. (1987). Formative evaluation: A process required in computer-assisted instruction. Educational Technology, November, 26-30.
- Streit, L., Davis, I., & Landner, C. (1986). Structuring text: Creating cost-effective training manuals. Educational Technology, September, 29-31.
- Taylor, R. & Cunniff, N. (1988). Moving computing and education beyond rhetoric. Teachers College Record, 89(3), 360-372.
- Tyler, R. (1942). General statement on education. Journal of Educational Research, 35, 492-501.